Physics 1C

Winter 2010 Final Exam form A

1) Radioactive Decay ^{32}P $T_{1/2} = 14.3$ days

5.0 μCi → after 60 days

$$N = N_0 \left(\tfrac{1}{2}\right)^{t/T_{1/2}}$$

Fraction Remaining $\frac{N}{N_0} = \left(\tfrac{1}{2}\right)^{t/T_{1/2}} = \left(\tfrac{1}{2}\right)^{60/14.3} = 5.5 \times 10^{-2}$

$$R = \lambda N$$

Then $R = R_0 \left(\frac{N}{N_0}\right) = 5.0\,(5.5 \times 10^{-2})\,\mu Ci = \boxed{0.27\,\mu Ci}$

2) Radioactivity – ^{60}Co $T_{1/2} = 5.27$ yrs $N = 2 \times 10^{17}$

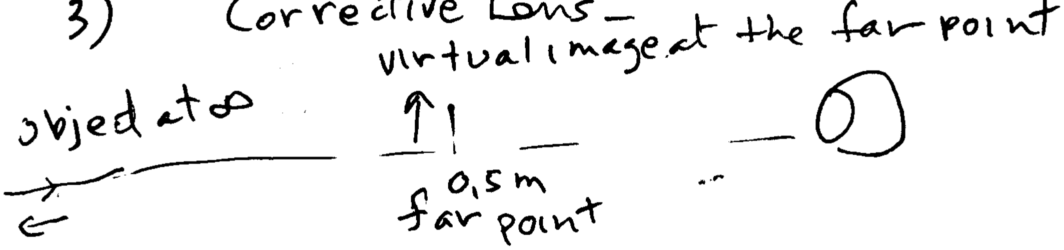
$$\lambda = \frac{0.693}{T_{1/2}} = \frac{0.693}{5.27\,yr\left(\frac{365\,day}{yr}\right)\left(\frac{24\,hr}{day}\right)\left(\frac{60\,min}{hr}\right)\left(\frac{60\,s}{min}\right)}$$

$$= 4.17 \times 10^{-9}\ s^{-1}$$

$$R = \lambda N = \frac{4.17 \times 10^{-9}\,s^{-1}\,(2 \times 10^{17})}{3.7 \times 10^{10}\ dps/Ci} = 2.3 \times 10^{-2}\ Ci$$

$\boxed{23\ mCi}$

3) Corrective Lens –



$p = \infty$ $q = -0.5$ m

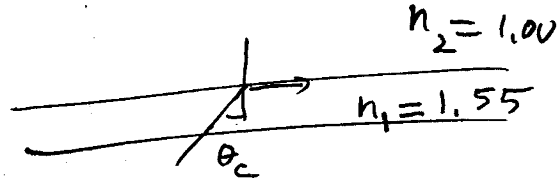
$$\frac{1}{p} + \frac{1}{q} = \frac{1}{f}$$

$$\frac{1}{\infty} + \frac{1}{-0.5} = \frac{1}{f}$$

$f = -0.5$ m $P = \frac{1}{f} = \frac{1}{-0.5}$

$\boxed{P = -2}$

4) Optical fiber



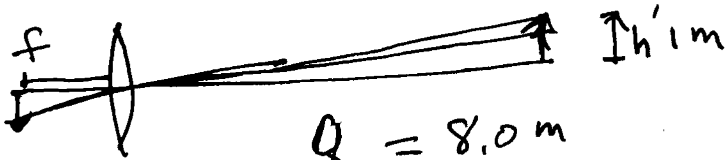
for total internal reflection

$$n_1 \sin\theta_c = n_2 \sin 90 = 1$$

$$\sin\theta_c = \frac{1}{n_1} = \frac{1}{1.55} = 0.645$$

$$\boxed{\theta_c = 40^\circ}$$

5)



$q = 8.0\,m$

Real object $\frac{h'}{h} = m = -\frac{q}{p} = -\frac{1.0m}{5\times10^{-3}m} = -200$

$$p = \frac{q}{200} = \frac{8m}{200} = 4\times10^{-2}m = 40\,mm$$

for $q >> p$ $f \cong p = \boxed{40\,mm}$

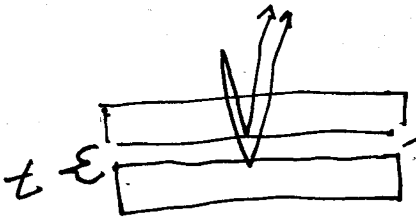
or solve for f

$$\frac{1}{p} + \frac{1}{q} = \frac{1}{f}$$

$$f = \frac{pq}{p+q} = \frac{(40\times10^{-3}m)(8\,m)}{8 + 40\times10^{-3}\,m} = \boxed{3.98\times10^{-2}m}$$

6) An incandescent light bulb has a spectrum like that of blackbody radiation at a temperature of ~ 3,000 - 4,000 K. This has a lot of <u>infrared radiation</u> which is not seen by the human eye & is not useful for vision.

7)

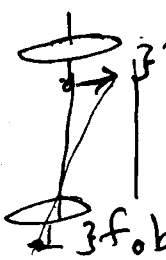


The light reflected from the two surfaces are out of phase by 180° because the first reflected beam is not phase shifted but the second one is. Therefore the condition for constructive interference is

$$2t = (m+\tfrac{1}{2})\lambda \quad \text{the lowest } t \text{ has } m=0$$

$$t = \frac{1}{4}\lambda = \frac{1}{4}\,600\,nm = \boxed{150\,nm}$$

8)

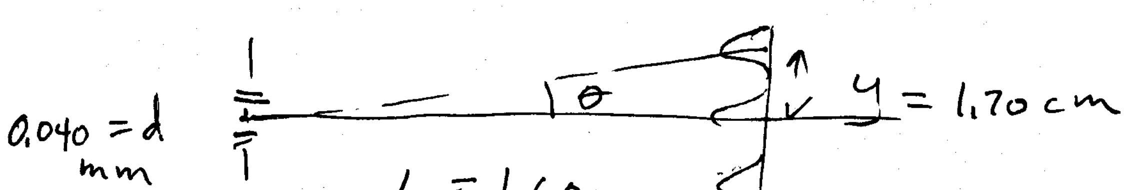


The magnification of a microscope is approximately

$$m = \frac{L}{f_{ob}}\,\frac{25\,cm}{f_{eye}} = \frac{12\times10^{-2}\,m}{10\times10^{-3}\,m}\,\frac{25\times10^{-2}\,m}{20\times10^{-3}\,m}$$

$$m = \boxed{150}$$

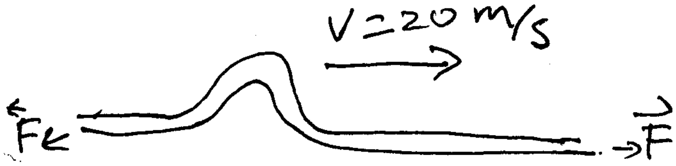
9) Youngs double slit experiment



$$d\sin\theta = m\lambda \qquad \sin\theta \cong \frac{y}{L}$$

$$\lambda = d\,\frac{y}{L} = 0.040\times10^{-3}\,m\left(\frac{1.70\times10^{-2}\,m}{1.60\,m}\right) = 4.25\times10^{-7}\,m$$

$$= \boxed{425\,nm}$$

10) 

Wave on a string -

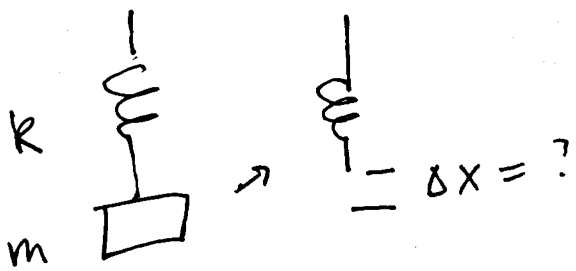
L = 1.0 m

m = 2.0 g

$$v = \sqrt{\frac{F}{m/L}}$$

$$v^2 = \frac{F L}{m}$$

$$F = \frac{m v^2}{L} = \frac{2.0 \times 10^{-3}\,kg\,(20\,m/s)^2}{1.0\,m} = \boxed{0.8\,N}$$

11.) 

f = 2.5 Hz

$$\omega = \sqrt{\frac{k}{m}} = 2\pi f$$

$$F = mg = k\,\Delta x$$

$$k = \frac{mg}{\Delta x}$$

substitute

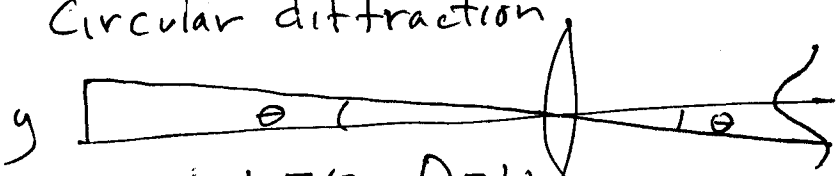
$$\sqrt{\frac{\cancel{m}g}{\Delta x\,\cancel{m}}} = 2\pi f = \sqrt{\frac{g}{\Delta x}}$$

Solve for Δx

$$\Delta x = \frac{g}{4\pi^2 f^2} = \frac{9.8\,m/s^2}{4\pi^2 (2.5)^2} = 4 \times 10^{-2}\,m$$

$\boxed{4\,cm}$

12) Circular diffraction



$L = 10\,m \quad D = 1.2\,cm$

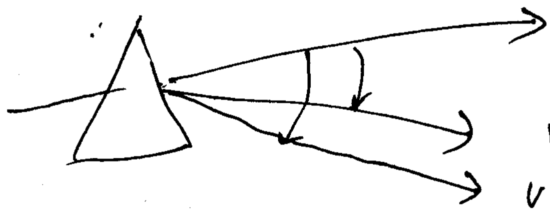
in the Rayleigh limit

$$\theta_{min} = 1.22\frac{\lambda}{D} = \frac{y}{L} \quad \text{(small angle approximation)}$$

$$y = \frac{1.22\,\lambda L}{D} = \frac{1.22(500\times10^{-9}\,m)(10\,m)}{1.2\times10^{-2}\,m} =$$

$$y = 5.1\times10^{-4}\,m = \boxed{0.51\,mm}$$

13)

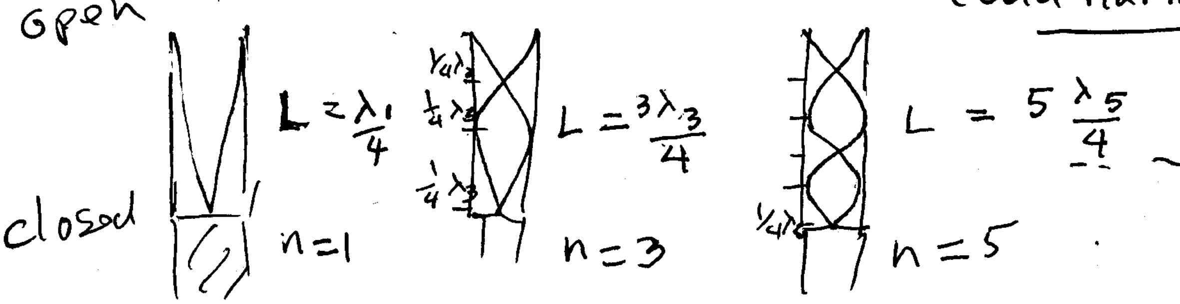


red

violet (largest n)

The deviation is due to an increase in refractive index of the prisim compared to air. The refratwe index for violet light is larger than that for other colors. so the deviation angle is largest

14 Resonance in an air column – at 300 Hz
possible standing waves – (odd harmonics)



14. continued -
The possible frequencies for the standing waves are

$$f_n = n \frac{V}{4L}$$

The possible values of L are

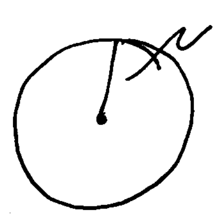
$$L = n \frac{V}{4 f_n}$$

for $n = 1$ $\quad L = \dfrac{(1)(340\ m/s)}{4\ (300\ Hz)} = 0.28\ m$

for $n = 3$ $\quad L = \dfrac{(3)(340)}{4\ (300\ Hz)} = \boxed{0.85\ m}$

for $n = 5$ $\quad L = \dfrac{5(340)}{4(300\ Hz)} = 1.~~42~~ m$ too long

15) Bohr atom



r = 0.053 nm

n = 1 ground state

angular momentum is quantized

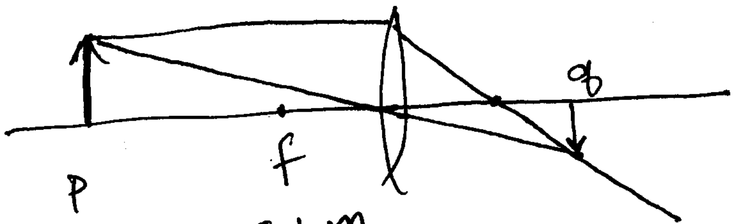
$$mvr = n\hbar = n\frac{h}{2\pi}$$

$$2\pi r = n\frac{h}{mv} = n\lambda \quad \left(\text{de Broglie waveleth } \lambda = \frac{h}{mv}\right.$$

for $n = 1$

$$\lambda = 2\pi r = 2\pi(0.053\ nm) = \boxed{0.33\ nm}$$

16)



0.3 m 0.1 m

$$\frac{1}{p} + \frac{1}{q} = \frac{1}{f}$$

$$q = \frac{pf}{p-f} = \frac{(0.3)(0.1)}{0.3-0.1} = 0.15\text{ m}$$ **real**

$$m = -\frac{q}{p} = -\frac{0.15}{0.30} = -0.5$$ **reduced**

17) In a nuclear reactor the moderator is a substance used to <u>slowdown the fast neutrons</u> to enable them to initiate fission reaction with the ^{235}U nuclei.

18)

$L = 0.70\text{ m}$ $f_1 = 250\text{ Hz}$

$m = 0.3\text{ g}$

$$f_1 = \frac{v}{\lambda_1} = \frac{v}{2L}$$

$$v = \sqrt{\frac{F}{m/L}} = \sqrt{\frac{FL}{m}}$$

$$f_1 = \frac{1}{2L}\sqrt{\frac{FL}{m}} = \frac{1}{2}\sqrt{\frac{F}{mL}}$$

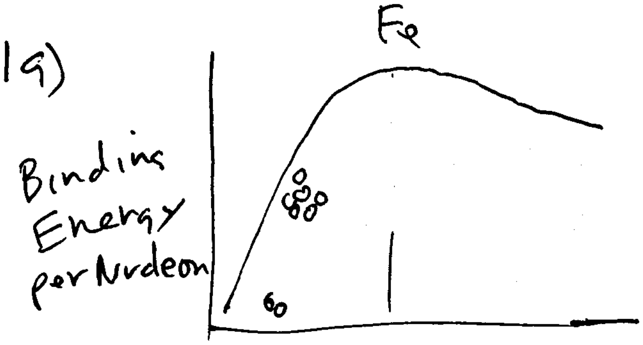
$$f_1^2 = \frac{1}{4}\left(\frac{F}{mL}\right)$$

18 continued.

$$F = 4 m L f_1^2 = 4(0.3\times10^{-3}\,kg)(0.7\,m)(250\,Hz)^2$$

$$F = \boxed{53\,N}$$

19)



at low Z the binding energy per nucleon increases with Z because of increasing near neighbor contacts. These contacts increase the energy due to the short range nuclear force.

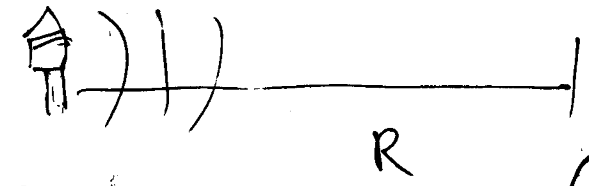
20)

$f = -0.25$

$$\frac{1}{p} + \frac{1}{q} = \frac{1}{f}$$

$$q = \frac{pf}{p-f} = \frac{(1.0)(-0.25)}{1-(-0.25)} = -0.20$$

$$m = -\frac{q}{p} = -\frac{(-0.20)}{1} = \boxed{0.20}$$

21) 

Siren

$P = 10W$

$\beta = 70 dB$

$$\beta = 10 \log \frac{I}{I_0} = 70 \, dB$$

$$\log \frac{I}{I_0} = \frac{70}{10} = 7$$

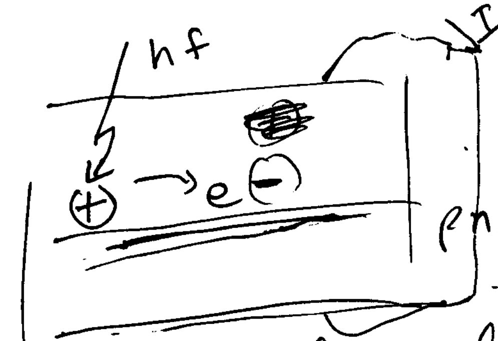
$$I = I_0 10^7 = 10^{-12} W/m^2 \times 10^7 = 10^{-5} W/m^2$$

for sound spreading in all directions

$$I = \frac{P}{4\pi R^2}$$

$$R^2 = \frac{P}{4\pi I}$$

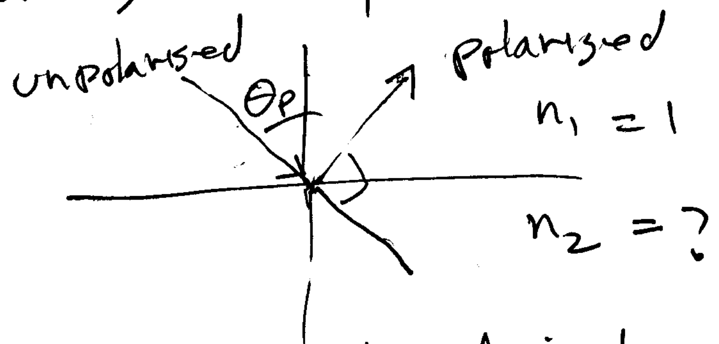
$$R = \sqrt{\frac{P}{4\pi I}} = \sqrt{\frac{10 W}{4\pi 10^{-5} W/m^2}} = \boxed{280 m}$$

22) 

~~The~~ Solar cell

In the solar cell a photon excites an electron to the conduction band creating an electron - hole pair. the electron & hole are separated across the pn junction generating a current flow.

23) Polarization by reflection

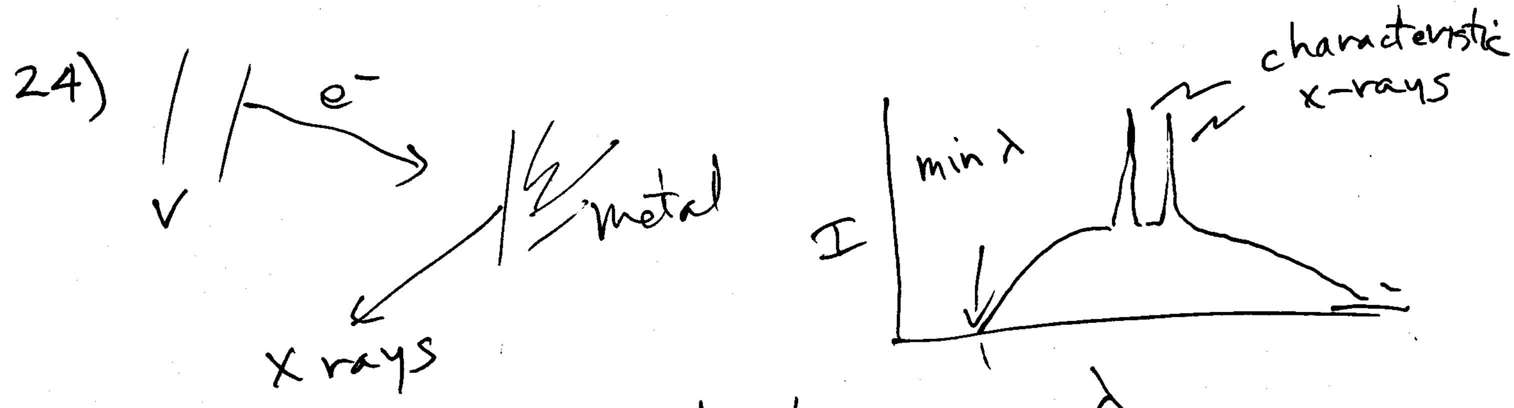


for complete polarization of reflected light

$$\tan\theta_p = \frac{n_2}{n_1} = n_2$$

$$n_2 = \tan 55° = \boxed{1.43}$$

24)



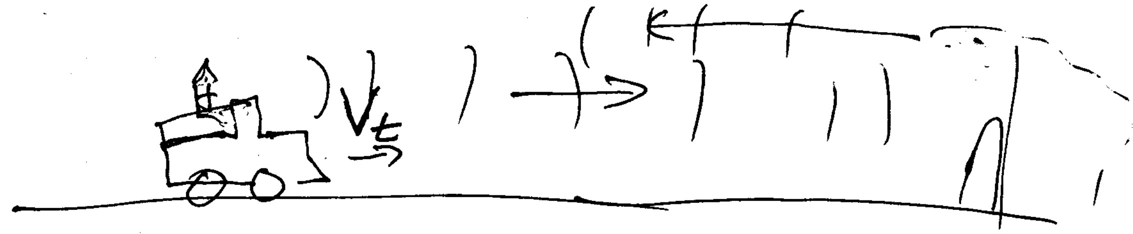
The sharp bands due to characteristic X rays have energies that are due to electronic energies of the metal and do <u>not depend</u> on the energy of the electron.

The broad continuum due to conversion of kinetic energy of the electron to X-rays <u>depends</u> on the <u>energy</u> of the electron.

The minimum wavelength depends on the kinetic energy of the electron

$$eV = h\frac{c}{\lambda}$$

25)



The sound heard by the observer on the train is Doppler shifted twice - the train acts as a moving source for the outgoing wave & acts as a moving observer of the reflected wave. Both effects increase the frequency heard by the observer.

$$f_{ob} = f_s \frac{V + V_t}{V - V_t}$$

the beat frequency is

$$f_b = f_{ob} - f_s = \left(\frac{V + V_t}{V - V_t} - 1\right) f_s$$

$$f_b = \left(\frac{340 + 30}{340 - 30} - 1\right) 800\,Hz$$ ~~[illegible]~~

$$f_b = \boxed{155\ Hz}$$